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(54) Foam Material with Noise-Reducing Properties

(57) A new PU foam material, at least predominantly of open-pore consistency, with noise-reducing properties is demonstrated, which can be glued onto a thin-wall support material and which has both airborne and solid-borne soundproofing properties. The foam material is distinguished by a construction based on Ricinus oil and possibly polyalcohol, especially polyglycol, as well as a material density of at least 120 kgm^{-3}. The material density can be dictated by additives of low-cost organic and/or inorganic fillers. In particular, the proportion of the polyalcohol determines the temperature at which maximum soundproofing is achieved. The proportion can be different in places, so that optimal soundproofing can be achieved depending on the locally achieved operating temperature of the wall being soundproofed. The overall layer thickness can be reduced by providing a flexible, especially a deflection-resistant surface covering of the foam material with improvement of the solid-borne and the airborne soundproofing.

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Claims

1. Predominantly open-pore PU foam material with noise-reducing properties, which can be glued onto a thin-wall support material, characterized by a composition based on Ricinus oil and a material density of at least 120 kgm^{-3}.

2. Foam material per Claim 1, characterized by an addition of polyalcohol.

3. Foam material per Claim 1 or 2, characterized by an OH number between 150 and 250.

4. Foam material per one of Claims 1 to 3, characterized by additions of fillers to increase the material density.

5. Foam material per one of Claims 1 to 4, characterized by a flexible surface covering (9.3) of the foam material (9.2) to increase its solid-borne soundproofing and its airborne soundproofing.

6. Foam material per Claim 5, characterized in that the surface covering (9.3) is deflection resistant.

7. Foam material per one of Claims 1 to 6, characterized in that the mix ratio is chosen so that the maximum soundproofing is achieved at a predetermined temperature.

8. Foam material per Claim 7, characterized in that the mix ratio differs by location in order to adapt to given local varying temperatures.

9. Foam material per Claim 7 or 8, characterized in that the polyalcohol proportion is increased for higher given temperatures.

10. Foam material per one of Claims 1 to 9, characterized in that the polyalcohol is a polyglycol.

11. Foam material per one of Claims 1 to 10, characterized in that the foam material (9.2) has recesses (9.6) in areas where the corresponding region of the support material (9.1) requires no local soundproofing.

12. Foam material per one of Claims 1 to 11, characterized in that the foam material is configured as a self-supporting molded piece or sheet piece.

Foam Material with Noise-Reducing Properties

The invention concerns an at least predominantly open-pore PU foam material with noise-reducing properties, which can be glued onto a thin-wall support material.

An open-pore polyurethane foam with viscoelastic properties is known from DE-OS 28 35 329, defined by OH numbers below 150.

Foam materials of this kind are used for various soundproofing of different regions of a surface giving off sound, e.g., the body of a vehicle. Now, it has been established that, for example, different surface temperatures occur in the front wall region of vehicles than in the region of the floor. Thus, based on the known temperature dependency in the given case, it is necessary to adjust the foam material to a predetermined operating temperature of the soundproofing wall, in order to achieve an optimal loss factor.

The solid-borne soundproofing of conventional non-ballasted polyurethane foams is negligible. On the other hand, solid-borne soundproofing foams have become familiar from the above-mentioned publication. However, their loss factors are relatively low, and, moreover, the maximum soundproofing is achieved at low temperatures, in particular, temperatures which are of little practical interest (for example, in motor vehicles).

Furthermore, no useful airborne soundproofing is expected in general from open-pore or substantially open-pore foams.

Therefore, the problem of the invention is to indicate an at least predominantly open-pore PU foam material that is viscoelastic and that has favorable solid-borne and airborne soundproofing qualities.

The problem is solved according to the invention by a foam material with a composition based on Ricinus oil and a material density of at least 120 kgm^{-3}.

Advantageously, the composition is based on Ricinus oil and polyalcohol.

Preferably, moreover, the foam material has a high OH number in the range between 150 and 250.

The invention will be presented by the features of the subsidiary claims.

The maximum soundproofing for a particular operating temperature can be achieved by various material adjustments, in particular, by changing the mix ratio, especially between the polyol mixture and the diisocyanate (shifting of the coefficient). Moreover, surfaces not requiring any local muffling, yet which have to be muffled overall, can be handled by recesses in the foam material, without affecting the overall soundproofing. In this way, one can save on foam material. Moreover, the muffling is achieved in a simple and economical way, and an adjustment to locally varying temperatures is possible. In particular, it is possible to adapt the material inside a foam piece to locally varying temperatures.

Owing to a composition based on Ricinus oil, the maximum silencing is set at a particular temperature. By the adding of polyalcohol, the cross-linking is altered, which on the one hand changes the foam structure, and on the other hand can shift the maximum silencing to the desired temperature.

To increase the material density, one can add organic and/or inorganic fillers, which is not self-evident for foam materials (changes in the expanding agent added can bring about a decrease in density), in order to achieve the desired minimum density or produce a favorable price.

The solid-borne soundproofing of the invented foam material is relatively high and can reach loss factors d of as much as 0.3 for foam of customary thickness ratios between coating and support material.

Furthermore, the invented foam material can achieve an airborne soundproofing which constitutes a measurable improvement over a non-silenced support material, such as steel sheet of 1 mm thickness. Measurements by the Barytest method (DE-PS 22 12 828) even show differences in sound level greater than would be expected from the mass law.

Advantageously, flexible surface coverings and deflection-resistant surface coverings can be placed on the foam material, which can even further improve the solid-borne and the airborne soundproofing. In particular, the temperature bandwidth of the muffling is increased, being defined in that the loss factors d of the system in relation to the temperature are equal to or greater than 0.03.

Since, moreover, the relationship between the polyalcohol proportion and the temperature at which the maximum silencing is achieved is known, the foam being used for a particular object can be prepared in a specifically optimized way. On the one hand, the maximum silencing is shifted toward higher temperatures with increasing polyglycol proportion having a higher OH share than Ricinus oil, and moreover the shifting of the maximum silencing is a linear function of the change in the polyalcohol and especially the polyglycol proportion. At first, one will use the Ricinus oil by itself as material for adjusting the maximum muffling to a particular temperature, especially 20°C, and the maximum muffling will then be shifted, depending on the particular application, by adding in the other fractions, in particular, the polyalcohol fraction (e.g., polyglycol).

The invention will now be explained further by means of the characteristic curves presented in the drawing.

These show:

Figure 1, the relation between the loss factor and temperature for a first composition,
Figure 2, the relation between the loss factor and temperature for a second composition,
Figure 3, the relation between the loss factor and temperature of a known composition,
Figure 4, the relation between loss factor and temperature of the first composition with a surface covering,

Figure 5, the relation between loss factor and temperature of the second composition with a surface covering,
Figure 6, the relation between soundproofing and frequency of composition according to the invention with a first material thickness,
Figure 7, the relation between soundproofing and frequency of composition according to the invention with a second material thickness,
Figure 8, the relation between the differences in sound level and the frequency according to the Barytest method,
Figure 9, a perspective view of a foam material on a supporting material.

The curves presented in the figures with respect to the invented foam materials were obtained on the basis of the following compositions:

Composition 1

Ricinus oil	100 parts =	51.7%
Diisocyanate (MDI)	65 parts =	33.6%
Polyglycol (polyol for the cross-linking)	5 parts =	2.6%
Cell opener	20 parts =	10.3%
Dibutyl tin dilaurate (DBTDL)	0.5 parts =	0.3%
Water	1 part =	0.5%
Frigen (expanding agent)	2 parts =	1.0%
	193.5 parts =	100.0%

and

Composition 2

Ricinus oil	95 parts =	42.0%
Diisocyanate (MDI)	75 parts =	33.4%
Polyglycol	10 parts =	4.4%
Cell opener	20 parts =	8.8%
Dibutyl tin dilaurate (DBTDL)	0.5 parts =	0.2%
Water	1 part =	0.4%
Frigen	4 parts =	1.8%
Dabco (amine, accelerator)	0.5 parts =	0.2%
Barytes (inorganic filler)	20 parts =	8.8%
	226.0 parts =	100.0%

The material density of Composition 1 is around 175 kgm^{-3} and the material density of Composition 2 is around 180 kgm^{-3}.

The two compositions differ not only in the different fractions, especially that of the polyalcohol, but also in that Composition 1 has a softer adjustment than Composition 2.

These two compositions 1 and 2 are contained in a theoretical composition with

(A):	Ricinus oil	100 parts
	Polyalcohol	0-20 parts
	Filler	0-200 parts
	Expanding agent	0.5-10 parts
	Accelerator, cell regulator	as required

(B): Diisocyanate (MDI, NDI, TDI or the like) in stoichiometric amount.

Shifts in the coefficient are usual in this case.

Moreover, for the technical range in question, one has A:B ≈ 2:1. Not only can the adjustment component B be changed in the ratio to the mixture component A, but also the composition of mixture component A can be changed in order to alter the mix ratio.

Figures 1 to 5 show the loss factor at a frequency of 200 Hz with constant thickness ratio x as the parameter. The thickness ratio x = 20 means that a foam thickness of around 20 mm was placed on a steel plate of 1 mm, as the supporting material, and measured. Slight fluctuations in the layer thickness of the foam material (19 mm or 20 mm) revealed no major differences in practice. A comparison of curves 1.1 for x = 10.0 and 1.2 for x = 20.0 in Figure 1 for Composition 1, moreover, shows that slight fluctuations in the layer thickness play no major role. Furthermore, the curve 1.2 in Figure 1 shows that the loss factor d reaches its maximum value in the range below 20°C for Composition 1 with a layer thickness ratio x = 20.0.

The curves 2.2 and 2.1 in Figure 2, which were determined for Composition 2 with other conditions being equal, show that the loss factor d for the layer thickness ratio x = 20.0 per curve 2.2 has its maximum slightly below 40°C for this Composition 2. This shifting of the soundproofing maximum toward higher temperatures is achieved by the higher polyglycol fraction of Composition 2.

Studies have shown that the shifting of the maximum silencing by changing the polyalcohol, especially the polyglycol fraction, stands in an essentially linear relationship with this change.

Curves 3.1, 3.2 and 3.3 per Figure 3, on the other hand, were plotted for the known foam material of DE-OS 28 35 329. The curves for the different layer thickness ratios 10.0, 20.0 and 30.0 show that the loss factor has a maximum silencing which lies at least below 0°C, which is of little importance to practical applications.

Moreover, it is shown that, in order to achieve the same loss factor at higher temperatures, substantial layer thicknesses are required, which is unfavorable in practice.

The foam material of the invention can be altered in relation to its loss factor by a locally varying composition so that the loss factor reaches its maximum in the region of a predetermined temperature, dictated by the particular application. In other respects, the foam material can have the same composition. In practice, one will first produce a composition based on (only) Ricinus oil, in which the Ricinus oil fraction essentially determines the loss factor, such that its maximum

Figure 1-5
x-axis: temperature, degrees Celsius
y-axis: loss factor d

Figure 6-7
x-axis: frequency, Hz
y-axis: soundproofing, dB

Figure 8
x-axis: frequency, Hz
y-axis: differences in sound level, dB